

PLANTS OF NAVAJO NATIONAL MONUMENT

J. D. Brotherson,¹ G. Nebeker,²
M. Skougard,³ and J. Fairchild¹

ABSTRACT.—The floristic composition of Navajo National Monument is presented. The flora of the monument consists of 293 species of vascular plants, representing 177 genera and 66 families. The species are scattered throughout 12 plant communities found within the monument. The flora is dominated by forbs (60 percent), followed by shrubs (16 percent), grasses (12 percent) and trees (5 percent). Betatakin canyon exhibits the greatest floristic richness with 223 species being represented and 123 species found only in that area. This is due primarily to two factors: (1) the greater variety of habitats available in the area, and (2) the much longer time the area has been protected from grazing and other manmade disturbance.

Navajo National Monument is in northeastern Arizona about 10 miles north and west of Black Mesa and Arizona Highway 160. The park headquarters are located on the Shonto Plateau near the head of Betatakin Canyon, a small side canyon of Tsegi Canyon. The principle attractions of the monument are three large Indian "cliff dwellings" of the Anasazi culture. These cliff dwellings are located in three separate canyons. Betatakin and Keet Seel canyons are located in the Tsegi Canyon complex, while Inscription House is situated about 20 miles west of Betatakin in Nitsin Canyon, a branch of Navajo Canyon.

All three units lie in pinyon-juniper slick-rock country which tends to influence heavily the environment of the monument. In the region are many deep-cut canyons with high-walled sandstone cliffs often reaching heights of 1000 feet above the streambeds. Within these deep canyons and along their walls, water (in the form of springs and seeps) is often present, creating unique habitats in which develop plant and animal communities often foreign to the overall pinyon-juniper type.

Because of the historical background of the park, almost all previous studies conducted at Navajo National Monument have been archaeological in nature. Dean (1969) points out that up to that time no botanical studies of Tsegi Canyon and its environs had been completed. Apparently, he was referring to the vascular flora, since Flowers

(1963) published a study on the lichens and mosses of Betatakin Canyon and vicinity. In his introduction, Flowers (1963) briefly lists some of the dominant plant species in and around Betatakin Canyon. Woodbury (1963) at the request of the National Park Service studied the features of Betatakin Canyon and vicinity for their interpretative value and use by the park personnel. His treatment is cursory and brief.

CLIMATE

Climatically, Navajo National Monument lies within the northeast sector of Arizona (Sellers 1964). There is a weather station at the park headquarters. Temperature and precipitation data for this station have appeared in *Climatological Data, Arizona* (U.S. Dept. of Commerce), since 1939.

The average annual temperature at Navajo National Monument headquarters is 50 F. The yearly maximum temperatures range from 94 to 101 F with an average of 96.1 F. The yearly low temperatures range from -10 to +8 F with an average of 1 F. The frost-free season ranges from 107 to 213 days with an average of 155 days.

The total annual precipitation at Betatakin has historically ranged from a low of 6.84 inches to a high of 18.79 inches with an average of 11.39 inches. The period of greatest precipitation is late summer and early fall. Rainfall within the canyons is variable and spotty, with localized

¹Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

²Department of Botany and Microbiology, Arizona State University, Tempe, Arizona 85281.

³United States Department of Agriculture, Houston, Texas.

cloudbursts occurring more often than general rains.

GEOLOGY

The geology of Tsegi Canyon has been treated by a number of authors (Gregory 1916, 1917; Hack 1942, 1945; Harshbarger, Repenning, and Irwin 1957; Cooley 1958, 1962). Navajo Sandstone is the major geological formation in each of the three localities. At Keet Seel and Inscription House the Navajo Sandstone is the only exposed rock formation. At Betatakin the Kayenta formation outcrops beneath the Navajo formation and can be observed in some locations in the lower reaches of the canyon. In all three canyons the Navajo Sandstone forms tall, rather sheer cliffs, up to 700 feet in height. At the base of these cliffs in each canyon, talus accumulations can be found, while the canyon bottoms are filled with deep deposits of sandy alluvium (quaternary fill). In Keet Seel and Nitsin Canyons these alluvial deposits are deeply eroded. In Betatakin Canyon the alluvial deposits are less extensive and not nearly so thick. They are underlain by the Kayenta formation in the lower half of the canyon and are deeply eroded, as is more characteristic of the canyon floor throughout the Tsegi Canyon system.

PLANT COMMUNITIES

In line with the unique geological and habitat features of Navajo National Monument, the communities within its boundaries are varied and in some cases unique. Twelve community (association) types (Table 1) are encountered within the monument. Of these only one (Pinyon-Juniper mixed shrub) is found in all segments of the monument. Five of the remaining 11 community types are found in 2 of the monument areas while 6 of the types are restricted to a single segment.

Because of the uniqueness of the Betatakin Canyon area, the vegetation there is highly different and distinct when compared with adjacent Tsegi Canyon and surrounding areas. Of special note is the presence in the canyon of a complex of species (i.e., *Populus tremuloides*, *Pseudotsuga menziesii*, *Mahonia repens*, *Symphoricarpos vaccinioides*, etc.) more often associated with high mountain rather than desert habitat. These species are found in the canyon because of favorable moisture regimes created by the canyon geology and Navajo Sandstone hydrology.

Flora of the Monument

The known flora of Navajo National Monument consists of 293 species of vascu-

TABLE 1. Vegetative communities (associations) encountered within the boundaries of Navajo National Monument and the percent of area they occupy.

Vegetation type	Monument segment		
	Inscription House	Keet Seel	Batatakin
	Percent of area covered	Percent of area covered	Percent of area covered
Streamside-tree	1.8		
Slickrock-scattered shrub	35.0	12.6	
Atriplex-grass	25.9	0.2	
Talus slope	11.3	9.3	
Mixed weed		13.5	
Pinyon-juniper-mixed shrub	26.0	59.6	43.5
Oak		4.8	2.4
Hanging garden		**T	T
Pinyon-juniper-sage			49.9
Pinyon-juniper-grass			3.1
Douglas Fir			0.4
Aspen			.7

*Total acreage equals:
 Inscription House = 40
 Keet Seel = 40
 Betatakin = 452

**T = trace

lar plants, representing 177 genera and 66 families. Of these species, 73 percent belong to the plant families listed in Table 2. These figures indicate the relative plant family composition of the monument. When comparisons are made with other studies (Brotherson 1967, Campbell 1977, Allan 1977) done in somewhat comparable areas of the Great Basin (Table 2), 7 of the 17 plant families listed are found to be represented in the floras of all 4 locations. As can be seen from the table, Arches National Park (Allan 1977) is the most similar in its dominant family composition to that of Navajo National Monument, differing only in 5 of the 17 families listed. The studies done in the Uintah Basin and Kaiparowits areas show high degrees of similarity to each other, differing only in one major plant family as well as being dominated by 9 of the 17 plant families listed in the table. In light of these facts it is of interest to note that the Navajo National Monument and Arches National Park areas have as their major geological formations sandstone while the Kaiparowits and Uintah Basin study areas are underlain mainly by geological formations high in clay. The ecological and/or phytogeographical significance of the dominance of these 17 plant families and/or their relationship to the general ge-

ology of the area is not known; however, further investigation along such lines tends to hold interest.

The species richness of the different segments of the Navajo National Monument is shown in Table 3. As can be seen, the Betatakin area exhibits more than twice as many species in its vegetation as can be found in the other areas. It also contains the greatest number of species found in only one of the monument areas. This would primarily be due to two factors: (1) the much longer time the area has been protected from grazing and other man-made disturbance, and (2) the greater variety of habitats available in the area.

The life-form and/or growth habitat characteristics of the flora are summarized in Tables 4 and 5. Native species number 270, 92.2 percent of the total flora. Twenty-three species are introduced. These include such species as *Tamarix ramosissima*, *Elaeagnus angustifolia*, *Chenopodium album*, *Salsola iberica*, *Sisymbrium altissimum*, *Melilotus alba*, and other species of a weedy nature. The herbaceous types of growth habit account for almost 75 percent of the species, with shrubs and trees contributing together about 20 percent of the total. In area coverage, however, the tree-

TABLE 2. Dominant plant family composition of Navajo National Monument and other great basin sites.

Family	Navajo National Monument	Kaiparowits	Arches National Park	Uintah Basin
Asteraceae	21.2	21.4	22.0	22.0
Poaceae	12.6	15.5	13.7	9.3
Brassicaceae	4.4	4.8	4.5	8.7
Fabaceae	4.4	4.8	6.9	5.8
Rosaceae	3.1		1.7	
Nyctaginaceae	3.1			
Cactaceae	3.1		1.7	
Boraginaceae	2.7	4.8	2.8	5.7
Polmoniaceae	2.7	8.3		4.0
Scrophulariaceae	2.7		2.8	5.7
Chenopodiaceae	2.4	10.7	6.6	5.8
Ranunculaceae	2.4			
Solanaceae	2.4			
Polygonaceae	2.0	4.8	3.3	5.7
Cyperaceae			1.9	
Liliaceae	2.0		1.9	
Salicaceae	2.0		1.7	
Total	73.2	75.1	71.5	72.7

and shrub-dominated vegetation types are the most widespread in the monument.

Checklist

The present list of plant species is the result of specimen collection at Navajo National Monument that has extended over a period of more than 45 years. Personnel associated with the park service began collections during the late 1930s and early 1940s. Scientists from Brigham Young University began work in the monument in the summer of 1972. Since that time regular visits have been made to the area and collections have been made throughout the growing season.

TABLE 3. Floristic richness of the different segments of Navajo National Monument.

Area of Monument	No. of species	No. of species found only at area in question
Betatakin	223	123
Keet Seal	108	16
Inscription House	108	31

TABLE 4. Plant characteristics and generalized life forms of the flora of Navajo National Monument.

Category	No. of species in category	Percent of total
Total no. of species	293	100.0
Native species	270	92.2
Introduced species	23	7.8
Perennial species	224	76.5
Biennial species	21	7.2
Annual species	48	16.4

TABLE 5. Growth habit characteristics of the flora of Navajo National Monument.

Category	No. of species in category	Percent of total
Trees	14	4.8
Shrubs	49	16.7
Forbs	176	60.1
Grasses	37	12.6
Sedges	4	1.4
Vines	1	.3
Other	12	4.1

Over the years the area has been visited and collections made by: M. Wetherill, 1930-1938; J. W. Brewer, 1934-1947; S. P. Brewer, 1941; E. Lehnert, 1960; E. Jackson, 1961; W. S. Phillips, 1964; J. M. Rominger, 1965; M. Skougard and G. Nebeker, 1972-1973; J. Brotherson, 1972-1977; and J. Fairchild, 1977. In the following list the specimens upon which the species are based are designated and the collectors' names abbreviated as indicated below:

MW	M. Wetherill
JWB	J. W. Brewer
SPB	S. P. Brewer
EL	E. Lehnert
EJ	E. Jackson
WSP	W. S. Phillips
JMR	J. M. Rominger
SN	M. Skougard and G. Nebeker
JF	J. Fairchild
JDB	J. D. Brotherson

Each species entry is also designated as to certain plant characteristics and according to the section of the monument in which it was found growing. These abbreviations are as follows:

P	Perennial
B	Biennial
A	Annual
N	Native
I	Introduced
T	Tree
S	Shrub
F	Forb
G	Grass
GI	Sedge
NV	Non-vascular
V	Vine
b	Betatakin
k	Keet Seal
i	Inscription House

The following list of families, genera, and species is arranged in alphabetical order for ease of reference. Plant identification follows *Arizona Flora* (Kearney and Peebles 1960), *Seed Plants of Northern Arizona* (McDougal 1973), *Manual of the Plants of Colorado* (Harrington 1964) and *Utah Plants* (Welsh and Moore 1973).

TAXA	PLANT CHARACTERISTICS
SUBDIVISION LYCOPSIDA	
Selaginella	
<i>Selaginella mutica</i> D. C. Eaton	
(WSP 3617, 19 June 1964)	PNNVb

SUBDIVISION SPHENOPSIDA		JF 15, 30 August 1977; JF 50,	
Equisetaceae		22 July 1977)	PNFbi
<i>Equisetum hyemale</i> L. (WSP, 19		<i>Cryptantha pterocarya</i> (Torr.)	
June 1964)		Greene (SN, 3 July 1972)	ANFb
SUBDIVISION PTEROPSIDA		<i>Lappula occidentalis</i> (Wats.)	
Class Gymnospermae		Greene (JF 222, 5 May 1977)	AIFb
Cupressaceae		<i>Lappula redowskii</i> (Hornem.)	
<i>Juniperus osteosperma</i> (Torr.)		Greene (SN 70, 9 June 1972;	
Little (SN 156; JF 4, 25 July		JF 189, 3 June 1977; MW	
1977)		G-2, 15 May 1937)	AIFb
Ephedraceae		<i>Lithospermum multiflorum</i> Torr.	
<i>Ephedra viridis</i> Coville (SN 125;		(JF 40, 14 July 1977)	PNFb
JF 256, 17 May 1977)		Cactaceae	
Pinaceae		<i>Coryphantha vivipara</i> (Nutt.)	
<i>Pinus edulis</i> Engelm. (SN 94;		Britton & Rose (JF 90, 10	
JMR 389-65, 22 August 1965)		June 1977)	PNSk
<i>Pseudotsuga menziesii</i> (Mirb.)		<i>Echinocereus fendleri</i> (Engelm.)	
Franc (SN)		Rumpler (JWB NB 74, 17	
		June 1941)	PNSbk
Class Angiospermae		<i>Echinocereus triglochidiatus</i>	
Subclass Dicotyledoneae		Engelm. (SN 325, 19 June	
Aceraceae		1973)	PNSb
<i>Acer negundo</i> L. (JWB NB 17,		<i>Opuntia erinacea</i> Engelm.	
7 June 1934; SN 264, 17 May		(JWB NB 78, 21 June 1941)	PNSbk
1973)		<i>Opuntia fragilis</i> (Nutt.) Haw.	
		(JWB H-4, 19 June 1941)	PNSb
Amaranthaceae		<i>Opuntia polycantha</i> Haw. (SN	
<i>Amaranthus albus</i> L. (JF 130,		331, 20 June 1973; JF 91, 10	
25 June 1977)		July 1977)	PNSbk
<i>Amaranthus leucocarpus</i> Wats.		<i>Opuntia whipplei</i> Engelm. &	
(JF 18, 28 August 1977)		Bigel. (JF 277, 30 June 1977)	PNSi
Anacardiaceae		<i>Sclerocactus parviflorus</i> Clover	
<i>Rhus trilobata</i> Nutt. (SN 227, 3		& Jotter (SN)	PNSb
July 1972)		<i>Sclerocactus whipplei</i> (Engelm.	
<i>Toxicodendron radicans</i> L.		& Bigel.) Britt. & Rose (JWB	
(MW 413)		NB 75, 19 June 1941; SN)	PNSbk
Apocynaceae		Capparidaceae	
<i>Apocynum medium</i> Greene		<i>Cleome serrulata</i> Pursh (JWB	
(MW 431, 10 June 1935)		NB 21, 16 June 1939, MW	
		I-1, 8 August 1937; JF 109,	
Asclepiadaceae		25 June 1977)	ANFbik
<i>Asclepias subverticillata</i> (Gray)		Caprifoliaceae	
Vail (SN 175, 2 July 1972; JF		<i>Symphoricarpos vaccinioides</i>	
62, 1 September 1977)		Rydb. (SN 310, 2 June 1973)	PNSb
<i>Funastrum heterophyllum</i>		Caryophyllaceae	
(Engelm.) Standl (MW 221;		<i>Arenaria eastwoodiae</i> Rydb. (JF	
JF 19, 28 August 1977)		145, 30 June 1977)	PNFbik
Berberidaceae		Chenopodiaceae	
<i>Mahonia repens</i> G. Don (SN		<i>Atriplex canescens</i> (Pursh) Nutt.	
269, 17 May 1973; MW 459,		(MW 419, 27 June 1935; JF	
21 May 1935; EL, 17 April		203, 21 May 1977)	PNSbk
1960; JWB E 1, 9 May 1941)		<i>Chenopodium album</i> L. (JF 278,	
		13 August 1977)	AIFbik
Betulaceae		<i>Chenopodium fremontii</i> Wats.	
<i>Betula occidentalis</i> Hook. (SN		(MW K-1; JF 242, 30 June	
145, 1 July 1972; MW 457;		1977)	ANFbik
WSP 3615, 19 June 1964;		<i>Chenopodium glaucum</i> L. (SN 204,	
JWB NB 33, 17 July 1940)		3 July 1972; JF 136, 30 June	
		1977)	AIFik
Boraginaceae		<i>Chenopodium pratericola</i> Rydb.	
<i>Cryptantha confertiflora</i>		(JF 160, 30 June 1977)	ANFik
(Greene) Payson (JWB NB		<i>Kochia scoparia</i> (L.) Schrad. (JF	
19, 12 June 1939)		115, 26 June 1977)	AIFi
<i>Cryptantha crassisepala</i> (Torr.		<i>Salsola iberica</i> Sennen &	
& Gray) Greene (SN)		Pau (SN)	AIFbik
<i>Cryptantha flava</i> (A. Nels.)			
Payson (SN 74, 9 June 1972;			
JF 93, 11 June 1977)			
<i>Cryptantha jamesii</i> (Torr.)			
Payson (SN 152, 1 July 1972;			

- Compositae (Asteraceae)
- Achillea millefolium* L. (SN 349, 24 July 1973) PNFbk
- Ambrosia acanthicarpa* Hook. (JF 25, 19 July 1977; JF 60, 1 September 1977) ANFik
- Ambrosia artemisiifolia* L. (JF 126, 25 June 1977) ANFik
- Antennaria marginata* Greene (JF 39, 14 July 1977) PNFb
- Antennaria neglecta* Greene (SN 150, 1 July 1972) PNFb
- Antennaria parvifolia* Nutt. (SN 120; JWB NB 58) PNFb
- Artemisia campestris* L. (JF 239, 16 June 1977) PNFb
- Artemisia dracunculus* L. (JWB NB 37, 17 July 1940; JF 103, 25 June 1977) PNFbik
- Artemisia frigida* Willd. (SN 359, 24 July 1973; JF 202, 21 May 1977; MW 451) PNSbik
- Artemisia ludoviciana* Nutt. (JF 87, 13 July 1977; JF 107, 25 June 1977) PNFbik
- Artemisia nova* A. Nels. (JF 279, 25 August 1977) PNSbk
- Artemisia pacifica* Nutt. (JF 3, 16 August 1977) PNFb
- Artemisia tridentata* Nutt. (MW 451; SN 360, 24 July 1973) PNSbik
- Aster arenosus* (Heller) Blake (JF 233, 30 June 1977) PNFb
- Aster hirtifolius* Blake (SPB M-5, 23 June 1941; SN 316, 19 June 1973) PNFb
- Brickellia californica* (Torr. & Gray) Gray (JF 129, 25 June 1977; JF 151, 30 June 1977) PNSbik
- Brickellia grandiflora* (Hook.) Nutt. (JF 228, 30 June 1977) PNFk
- Brickellia scabra* (Gray) A. Nels. (JF 133, 25 June 1977) PNSbik
- Chaenactis stevioides* H. & A. (SN 327, 20 June 1973) ANSbik
- Chrysothamnus depressus* Nutt. (JF 264, 16 May 1977) PNSi
- Chrysothamnus nauseosus* (Pall.) Britton (JF 121, 25 June 1977) PNSik
- Chrysothamnus pulchellus* (Gray) Greene (JWB, 24 July 1946) PNSbik
- Chrysothamnus viscidiflorus* (Hook.) Nutt. (JF 263, 16 May 1977) PNSbik
- Cirsium pulchellum* (Greene) Woot. & Standl. (JF 174, 30 June 1977) BNFbk
- Conyza canadensis* (L.) Cronquist (JF 155, 30 June 1977) ANFb
- Erigeron concinnus* (H. & A.) Torr. & Gray (SN 313, 19 June 1973; JF 88, 13 July 1977; JF 141, 30 June 1977) PNFbk
- Erigeron divergens* Torr. & Gray (SN 304, 1 June 1973; JWB NB-69, 19 June 1941; JWB NB-2, 21 May 1939; JF 13, 30 August 1977) BNFbi
- Erigeron flagellaris* Gray (JF 24, 20 July 1977; JF 54, 22 July 1977) BNFbi
- Erigeron glabellus* Nutt. (SN 163, 1 July 1972) BNFb
- Erigeron macranthus* Nutt. (MW M-7; JF 48, 14 July 1977; JF 55, 2 July 1977) PNFb
- Erigeron utahensis* Gray (JF 29, 1 September 1977; JF 56, 22 July 1977; JF 138, 30 June 1977) PNFbi
- Caillardia pinnatifida* Torr. (SN 97, 10 June 1972) PNFb
- Haplopappus nuttallii* Torr. & Gray (SN 137; MW 919-3157, 2 September 1938; JWB M-10; 23 June 1941) PNFbik
- Haplopappus scopulorum* (Jones) Blake (JF 12, 30 August 1977; JF 152, 30 June 1977) PNFbi
- Heterotheca villosa* (Pursh) Shinnars (SN 177, 2 July 1972; JF 33, 1 September 1977; JF 68, 25 July 1977; JF 108, 25 June 1977) PNFbik
- Hymenopappus filifolius* Hook. (SN 78, 9 June 1972; JF 44, 7 July 1977; JF 86, 13 July 1977; JF 89, 11 June 1977) PNFbk
- Hymenopappus lugens* Greene (JWB M-11, 17 June 1941) PNFb
- Hymenoxys acaulis* (Pursh) K. F. Parker (JWB NB 23, 12 June 1939; JF 45, 7 July 1977) PNFb
- Hymenoxys bigelovii* (Gray) K. F. Parker (SN 301, 1 June 1973; JF 83, 13 June 1977) PNFb
- Hymenoxys ivesiana* (Greene) Parker (JWB NB 23, 12 June 1939) PNFb
- Hymenoxys richardsonii* (Hook.) Cockerell (JF 235, 13 June 1977) PNFb
- Lactuca pulchella* (Pursh) DC. (SN 348, 22 July 1973; JWB M-12, 28 July 1940; JF 6, 25 July 1977) PNFbk
- Machaeranthera grindelioides* (Nutt.) Shinnars (SN 137; MW; JF 143, 30 June 1977) PNFbk
- Machaeranthera hansonii* Nels. (JF 11, 30 August 1977) PNFi
- Machaeranthera linearis* Greene (JMR 343 65, 21 August 1965) PNFbk
- Machaeranthera tephrodes* (Gray) Greene (JF 240, 30 June 1977) BNFb

- Malacothrix sonchoides* (Nutt.)
Torr. & Gray (SN) ANFbi
- Psilostrophe sparsiflora* (Gray)
A. Nels. (SN 161, 1 July 1972;
JF 114, 26 June 1977; MW
M-13; JF 139, 30 June 1977) PNFb
- Senecio longilobatus* Benth. (JF
67, 1 September 1977; JF 95,
11 June 1977) PNFbi
- Senecio multilobatus* Torr. &
Gray (JWB NB 70, 19 June
1941; JF 186, 3 June 1977) PNFbk
- Senecio uintahensis* (A. Nels.)
Greene (SN 100, 10 June
1972) PNFb
- Solidago canadensis* L. (SN 172,
1 July 1972) PNFb
- Solidago occidentalis* (Nutt.)
Torr. & Gray (SN 350, 24 July
1973) PNFb
- Stephanomeria exigua* Nutt.
(JMR 345-65, 21 August 1965;
SN, 3 July 1972; JF 105, 25
June 1977) ANFb
- Stephanomeria tenuifolia* (Torr.)
Hall (JDB 2502, 3 August
1977) PNFb
- Stephanomeria thurberi* Gray (JF
53, 22 July 1977) PNFb
- Taraxacum officinale* Weber (SN
273, 17 May 1973) PIFb
- Tetradymia canescens* DC. (SN
358, 24 July 1973; JF 161, 30
June 1977) PNSbik
- Townsendia incana* Nutt. (JWB
M-16, 18 June 1941; SN 62, 9
June 1972; JF 206, 21 May
1977) PNFb
- Verbesina encelioides* (Cav.)
Benth. & Hook. (JF 1, 1
September 1977) ANFi
- Xanthocephalum lucida* (Greene)
Shinners (JWB NB-30, 3 August
1940) PNSb
- Xanthocephalum sarothrae* (Pursh)
Shinners (MW M-9, 2 September
1937; SN 157, 11 June 1972;
JF 255, 17 May 1977) PNSbik
- Cornaceae
- Cornus stolonifera* Michx. (JWB
NB 39, August 1940; MW 41,
May 1935; SN 308, 2 June
1973) PNSb
- Crassulaceae
- Sedum stenopetalum* Pursh
(JWB NB 54, 28 May 1941) PNFb
- Cruciferae (Brassicaceae)
- Arabis perennans* S. Wats.
(JWB NB 46, 19 April 1941;
JF 220, 5 May 1977) PNFbi
- Arabis pulchra* Jones (EL, 17
April 1960) PNFb
- Descurainia pinnata* (Walt.)
Britton (JWB P-4, 23 June
1941; JF 156, 30 June 1977) ANFbk
- Descurainia sophia* (L.) Webb.
(EL, 17 April 1960; SN 73, 9
June 1972) AIFbik
- Erysimum asperum* DC. (JWB
NB 52, 30 May 1941; JWB
NB 7, 11 April 1939; SN 286,
21 May 1973; JF 225, 5 May
1977) PNFbk
- Lepidium montanum* Nutt. (SN
195, 3 July 1972; JF 63, 1
September 1977) PNFbik
- Lesquerella ludoviciana* (Nutt.)
S. Wats. (JWB NB 8, 20 May
1936; SN 303, 1 June 1973) PNFb
- Lesquerella rectipes* Woot. &
Standl. (JF 184, 3 June 1977) PNFb
- Sisymbrium altissimum* L. (JR
389-65, 22 August 1965; JF
158, 30 June 1977) AIFbk
- Streptanthella longirostris* (S.
Wats.) Rydb. (SN) ANFbik
- Streptanthus cordatus* Nutt. ex
Torr. & Gray (SN 75, 9 June
1972; JWB NB 34, 17 July
1940; JWB NB 59, 20 April
1941; EL, 17 April 1960; JF
135, 30 June 1977) PNFb
- Thelypodium integrifolium*
(Nutt.) Endl. (JF 2, 24 July
1977) BNFk
- Thlaspi fendleri* Gray (SN; JWB
NB 47, 19 April 1941) PNFb
- Elaeagnaceae
- Elaeagnus angustifolia* L. (JF
106, 25 June 1977) PITi
- Shepherdia rotundifolia* Parry
(SN 281, 17 May 1973; JF
217, 5 May 1977) PNSbik
- Ericaceae
- Arctostaphylos pungens* H. B.
K. (MW 109) PNSb
- Euphorbiaceae
- Euphorbia lurida* Engelm. (JWB
NB 56, 28 May 1941) PNFb
- Euphorbia micromera* Boiss. (JF
26, 19 July 1977) ANFi
- Fagaceae
- Quercus gambelii* Nutt. (SN 160,
1 July 1972; JF 214, 21 May
1977; JWB NB 40, 17 July
1940) PNTbk
- Quercus turbinella* Greene (JF
27, 1 September 1977) PNSi
- Fumariaceae
- Corydalis aurea* Willd. (SN 201) ANFb
- Geraniaceae
- Erodium cicutarium* (L.) L'Her
(SN 252, 8 May 1973) AIFbik
- Geranium atropurpureum* Heller
(SN 116, 10 June 1972; JWB
NB 28, 25 July 1940; JWB
NB 42, 17 July 1940; JF 75, 12
July 1977) PNFb
- Hydrophyllaceae

<i>Phacelia corrugata</i> A. Nels. (SN 245, 8 May 1973)	ANFb	JF 71, 20 July 1977; JF 85, 13 June 1977)	PNFbik
<i>Phacelia icesiana</i> Torr. (JWB 1080-1723a, 23 June 1941)	ANFbik	<i>Sphaeralcea parvifolia</i> A. Nels. (JWB NB 72, 19 June 1941; SN 68, 2 June 1972; JF 248, 16 May 1977)	PNFbik
Labiatae (Lamiaceae)			
<i>Moldovica parviflora</i> (Nutt.) Britt. & Brown (SN 218, 3 July 1973)	BNFb	Nyctaginaceae	
Leguminosae (Fabaceae)		<i>Abronia elliptica</i> A. Nels. (JWB NB 51, 27 May 1941; JF 187, 3 June 1977)	PNFbik
<i>Astragalus amphioxys</i> Gray (SN)	PNFb	<i>Abronia fragrans</i> Nutt. ex Hook. (SN)	PNFb
<i>Astragalus ceramicus</i> Sheld. (SN 103, 10 June 1972; JWB NB 10, 11 May 1939; JF 81, 16 June 1977)	PNFb	<i>Allionia incarnata</i> L. (JF 65, 1 September 1977)	PNFi
<i>Astragalus lentiginosus</i> Dougl. ex Hook. (SN 251, 8 May 1973; JF 70, 20 July 1977; JF 132, 25 June 1977)	PNFbik	<i>Allionia linearis</i> Pursh (JWB NB 20, 12 June 1939)	PNFb
<i>Astragalus mollissimus</i> Torr. var. <i>thompsonae</i> (Wats.) Barneby (SN 101, 10 June 1972; JF 84, 13 June 1977)	PNFb	<i>Mirabilis comatus</i> Standl. (SN 361, 24 July 1973)	PNFk
<i>Astragalus sesquiflorus</i> S. Wats. (EL, 17 April 1960; SN 276, 17 May 1973)	PNFb	<i>Mirabilis multiflora</i> (Torr.) Gray ex Torr. (SN 174, 2 July 1972; JF 21, 20 July 1977; JF 112, 25 June 1977)	PNFi
<i>Astragalus zionis</i> Jones (JF 317, 27 July 1977; JF 178, 5 May 1977)	PNFbik	<i>Mirabilis oxybaphoides</i> Gray (JF 34, 27 July 1977)	PNFk
<i>Lathyrus arizonicus</i> Britton (JF 261, 17 May 1977)	PNFb	<i>Oxybaphus linearis</i> (Pursh) Robins (JWB NB 20)	PNFb
<i>Lathyrus brachycalyx</i> Rydb. (SN 111, 10 May 1972; JF 211, 21 May 1977; JWB X-3, 11 May 1941)	PNFb	<i>Tripterocalyx wootonii</i> Standl. (JMR 385-65, 22 August 1965; JWB NB 67, 19 May 1941; JF 31, 1 September 1977)	ANFbi
<i>Lupinus argenteus</i> Pursh (JF 35, 27 July 1977)	PNFb	Oleaceae	
<i>Medicago sativa</i> L. (SN 105, 10 June 1972)	PIFb	<i>Fraxinus anomala</i> Torr. (MW 297)	PNTi
<i>Melilotus alba</i> Desr. (JF 57, 22 July 1977)	BIFb	Onagraceae	
<i>Melilotus officinalis</i> (L.) Lam. (JF 58, 22 July 1977)	BIFb	<i>Epilobium hornemanii</i> Reichenb. (JF 74, 24 July 1297)	PNFk
Linaceae		<i>Oenothera albicaulis</i> Pursh (SN 106, 10 June 1972)	ANFbi
<i>Linum aristatum</i> Engelm. ex Wisliz. (MW Z-1, 13 August 1937; SN; JF 30, 1 September 1977)	ANFi	<i>Oenothera caespitosa</i> Nutt. (SN 194; JF 92, 10 June 1977)	PNFbik
<i>Linum perenne</i> L. (MW 65, 27 May 1935)	PNFb	<i>Oenothera hookeri</i> Torr. & Gray. (JWB, 1941)	BNFb
Loasaceae		<i>Oenothera longissima</i> Rydb. (JF 43, 12 July 1977)	BNFb
<i>Mentzelia albicaulis</i> Dougl. (JWB NB 5, 11 May 1939; SN 338, 29 June 1973)	ANFb	<i>Oenothera pallida</i> Lindl. (JR 398-65, 22 August 1965; SN 217, 3 July 1972; JF 207, 21 May 1977)	PNFi
Loranthaceae		Plantaginaceae	
<i>Arceuthobium campylopodium</i> Engelm. (MW AB-1, 23 August 1937)	PNFb	<i>Plantago purshii</i> Roem. & Schult. (SN 333, 27 June 1973)	PNFb
<i>Phoradendron juniperinum</i> Engelm. (SN 198)	PNFb	Polemoniaceae	
Malvaceae		<i>Gilia aggregata</i> (Pursh) Spreng. (SN 58, 9 June 1972; JF 41, 18 July 1977)	PNFbik
<i>Sidalcea neomexicana</i> Gray (SN)	PNFb	<i>Gilia leptomeria</i> Gray (SN 283, 17 May 1973)	ANFbik
<i>Sphaeralcea coccinea</i> (Nutt.) Rydb. (SN 335, 29 June 1973;		<i>Gilia longiflora</i> (Torr.) G. Don. (JMR 341-65, 21 August 1965; JF 10, 30 August 1977; JF 4, 16 August 1977)	ANFbi
		<i>Gilia scopulorum</i> Jones (SN)	ANFb
		<i>Gilia subnuda</i> Torr. ex Gray	

(SN)	BNFb	213, 21 May 1977; SPB NB 62, 18 June 1941)	PNSb
<i>Leptodactylon pungens</i> (Torr.) Nutt. (SN 126, 10 June 1972; JF 146, 30 June 1977)	PNSbk	<i>Cercocarpus intricatus</i> S. Wats. (SN 261, 17 May 1973; JWB NB 63, 12 May 1941; MW 452, JF 218, 5 May 1977)	PNSbik
<i>Phlox austromontana</i> Coville (JF 262, 16 May 1977)	PNFb	<i>Cowania mexicana</i> D. Don. (SN 65)	PNSb
<i>Phlox longifolia</i> Nutt. (SN)	PNFbk	<i>Fallugia paradoxa</i> (D. Don.) Endl. (JF 64, 1 September 1977)	PNSi
Polygonaceae			
<i>Eriogonum alatum</i> Torr. in Sitgr. (SN 197, 3 July 1972; JF 46, 7 July 1977)	PNFb	<i>Holodiscus dumosus</i> (Nutt.) Heller (MW 919-3044; JWB 1080-1709, June 1942; MW 434)	PNSb
<i>Eriogonum cernuum</i> Nutt. (SN 235, 20 July 1972)	ANFb	<i>Prunus emarginata</i> (Dougl.) D. Dietr. (SN 288, 24 May 1973; JF 163, 30 June 1977)	PNTk
<i>Eriogonum corymbosum</i> Benth. in DC (JF 281, 1 September)	PNSi	<i>Prunus virginiana</i> L. (SN 309, 2 June 1973)	PNTb
<i>Eriogonum microthecum</i> Nutt. (EJ, 16 August 1961; JMR 338-65, 21 August 1965; SN 239, 24 July 1972; JF 244, 8 May 1977)	PNSb	<i>Purshia tridentata</i> (Pursh) DC. (SN 307, 1 June 1973)	PNSbk
<i>Eriogonum umbellatum</i> Torr. (JWB NB 35, 17 July 1940; JMR 334-65, 21 August 1965; JF 32, 1 September 1977)	PNSi	<i>Rosa woodsii</i> Lindl. (SN 113, 10 June 1972; JWB NB 16, 7 June 1939; JF 157, 30 June 1977)	PNSb
<i>Eriogonum umbellatum</i> Torr. var. <i>cognatum</i> Greene (JF 280, 1 September 1977)	PNFb	Rubiaceae	
Portulacaceae			
<i>Portulaca oleracea</i> L. (JF 14, 30 August 1977; JF 69, 20 July 1977)	AIFi	<i>Galium aparine</i> L. (JF 166, 30 June 1977)	ANFk
<i>Portulaca retusa</i> Engelm. (JF 73, 27 July 1977)	AIFk	<i>Galium triflorum</i> Michx. (SN 154, 1 July 1972)	PNFb
<i>Talinum brevifolium</i> Torr. (SN 173, 2 July 1972; JF 16, 30 August 1977)	PNFi	<i>Kelloggia galioides</i> Torr. (JF 241, 3 June 1977)	PNFbk
Primulaceae			
<i>Androsace septentrionalis</i> L. (JF 47, 14 July 1977)	ANFb	Salicaceae	
<i>Populus angustifolia</i> James (JF 281, 30 June 1977)			
<i>Populus fremontii</i> S. Wats. (SN 179)			
<i>Populus tremuloides</i> Michx. (SN 171)			
<i>Salix exigua</i> Nutt. (SN 181, 2 July 1972)			
<i>Salix goodingii</i> Ball (SN; JF 128, 25 June 1977)			
<i>Salix lasiolepis</i> Benth. (JF 208, 21 May 1977)			
Santalaceae			
<i>Comandra pallida</i> DC. (JF 149, 30 June 1977; JF 196, 31 May 1977)			
Saxifragaceae			
<i>Fendlera rupicola</i> Gray (SN 289, 24 May 1973; JF 212, 21 May 1977)			
<i>Heuchera parvifolia</i> Nutt. (SN 118, 10 June 1972)			
<i>Heuchera rubescens</i> Torr. (SN 311, 19 June 1973)			
<i>Ribes cereum</i> Dougl. (JF 142, 30 June 1977; JF 204, 21 May 1977)			
<i>Ribes leptanthum</i> Gray (JF 169, 30 June 1977; JF 205, 21 May 1977)			
<i>Ribes viscosissimum</i> Pursh (SN			
Rosaceae			
<i>Amelanchier utahensis</i> Koehne (SN 129, 10 June 1972; JF			

290, 24 May 1973)	PNSk	<i>Carex rossii</i> Boott (JF 172, 16 June 1977)	PNGlb
Scrophulariaceae		<i>Eleocharis macrostachya</i>	
<i>Castilleja linearifolia</i> Benth. (SN 96, 10 June 1972; JF 49, 22 July 1977; JF 134, 30 June 1977)	PNFbik	Britton (JF 28, 1 September 1977; JF 119, 25 June 1977)	PNGLbi
<i>Cordylanthus wrightii</i> Gray (JMR 340-65, 21 August 1965; EJ, 16 August 1961)	ANFb	Gramineae (Poaceae)	
<i>Mimulus eastwoodiae</i> Rydb. (SN 221; JF 20, 20 July 1977; JF 165, 30 June 1977)	PNFbik	<i>Agropyron caninum</i> (L.) Beauv. (SN 85, 10 June 1972; JF 182, 3 June 1977)	PNGbk
<i>Penstemon ambiguus</i> Torr. (EL; SN; JF 230, 18 May 1977)	PNSb	<i>Agrostis exarata</i> Trin. (SN 182, 2 July 1972)	PNGi
<i>Penstemon barbatus</i> (Cav.) Roth (JF 59, 22 July 1977)	PNFb	<i>Agrostis semiverticillata</i> (Forsk.) Christ. (SN 356, 24 July 1973; JF 38, 27 July 1977; JF 118, 25 June 1977)	PIGk
<i>Penstemon comarrhenus</i> Gray (JWB 27 June 1947; JF 162, 30 June 1977)	PNFb	<i>Alopecurus aequalis</i> Sobol. (SN 354, 24 July 1973)	PNGk
<i>Penstemon Eatoni</i> Gray (SN 108, 10 June 1972; JDB 2503, 3 August 1974)	PNFb	<i>Andropogon hallii</i> Hack. (JF 66, 1 September 1977)	PNGi
<i>Penstemon virgatus</i> Gray (JF 52, 12 July 1977)	PNFb	<i>Aristida arizonica</i> Vasey (SN 188, 2 July 1973)	PNGb
Solanaceae		<i>Aristida fendleriana</i> Steud. (JF 100, 25 June 1977; JF 117, 25 June 1977)	PNGbi
<i>Chamaesarcha coronopus</i> (Dunal) Gray (SN 183, 2 July 1972)	PNFi	<i>Bouteloua barbata</i> Lag. (JF 72, 1 September 1977)	ANGi
<i>Datura meteloides</i> DC. (JF 282, 30 June 1977)	ANFbik	<i>Bouteloua curtispindula</i> (Michx.) Torr. (SN 347, 29 June 1973)	PNGi
<i>Lycium pallidum</i> Miers. (SN; JF 98, 26 June 1977)	PNSi	<i>Bouteloua gracilis</i> (H.B.K.) Lag. (JF 284, 30 June 1977)	PNGb
<i>Nicotiana attenuata</i> Torr. (JMR 400-65, 22 August 1975)	PNFi	<i>Bromus carinatus</i> Hook. & Arn. (SN 224, 3 July 1972)	PNGbk
<i>Physalis fendleri</i> Gray (SN 158, 1 July 1972; JF 137, 30 June 1977)	PNFbi	<i>Bromus ciliatus</i> L. (SN 84, 10 June 1972; JF 181, 3 June 1977)	PNGb
<i>Physalis hederacfolia</i> Gray (JF 153, 30 June 1977)	PNFk	<i>Bromus marginatus</i> Nees (JF 168, 30 June 1977)	PNGb
<i>Solanum jamesii</i> Torr. (JF 17, 28 August 1977)	PNFk	<i>Bromus rubens</i> L. (JF 104, 25 June 1977)	AIGik
Tamaricaceae		<i>Bromus tectorum</i> L. (SN 207, 3 July 1973; JF 192, 3 June 1977)	AIGbik
<i>Tamarix ramosissima</i> Ledels. (JF 283, 30 June 1977)	PISi	<i>Elymus glaucus</i> Buckl. (JF 42, 18 July 1977)	PNGb
Umbelliferae (Apiaceae)		<i>Glyceria striata</i> (Lam.) Hitch. (JF 7, 25 July 1977)	PNGb
<i>Cymopterus newberryi</i> (S. Wats.) M. E. Jones (JWB, 16 May 1941)	PNFb	<i>Hordeum Leporinum</i> Link (SN)	ANGb
Urticaceae		<i>Lycurus phleoides</i> H.K.B. (JF 23, 20 July 1977)	PNGi
<i>Parietaria pennsylvanica</i> Muhl. (JF 123, 25 June 1977)	ANFi	<i>Muhlenbergia andina</i> (Nutt.) A. S. Hitchc. (JF 8, 1 September 1977)	PNGb
Verbenaceae		<i>Muhlenbergia curtifolia</i> Scribn. (JMR 332-65, 21 August 1965)	PNGi
<i>Verbena bracteata</i> Lag. & Rodr. (SN 337, 29 June 1973)	PNFb	<i>Muhlenbergia pungens</i> Thurb. (JMR 342-65, 21 August 1965; SN 243, 27 July 1972)	PNGb
Subclass Monocotyledoneae		<i>Muhlenbergia thurberi</i> Rydb. (JF 120, 25 June 1977)	PNGbi
Commelinaceae		<i>Munroa squarrosa</i> (Nutt.) Torr. (SN; JF 9, 30 August 1977; JF 61, 1 September 1977)	ANGi
<i>Tradescantia occidentalis</i> (Britt.) Smyth (SN 151; JF 80, 16 June 1977; JWB NB 22, 12 June 1939; JMR 335-65, 22 August 1965)	PNFbik	<i>Oryzopsis Hymenoides</i> (R. & S.) Riker (SN 343, 29 June 1973)	PNGbik
Cyperaceae			
<i>Carex occidentalis</i> Bailey (JF 51, 12 July 1977; JF 173, 16 June 1977)	PNGb		

Oryzopsis micrantha (Trin. & Rupr.) Thurb. (SN 86, 10 June 1972; JF 179, 3 June 1977) PNGb

Poa fendleriana Vasey (MW 7; MW 28; SN 275, 17 May 1973) PNGbk

Poa longiligula Scribn. & Williams (SN; MW 14; JF 94, 13 June 1977; JF 99, 25 June 1977) PNGbik

Poa pratensis L. (SN 357, 24 July 1973; JF 167, 30 June 1977) PIGbk

Polypogon monspeliensis (L.) Desf. (SN 351, 24 July 1973; JF 110, 25 June 1977) AIGbk

Puccinellia airoides (Nutt.) Wats. & Coult. (JF 170, 30 June 1977) PNGbk

Sitanion hystrix (Nutt.) J. G. Smith (SN 323, 19 June 1973; JF 82, 13 June 1977) PNGbik

Sporobolus airoides Torr. (JF 22, 19 July 1977) PNGik

Sporobolus cryptandrus (Torr.) Gray (JMR 344-65, 21 August 1965; SN 228, 3 July 1972; JF 96, 25 June 1977) PNGbik

Sporobolus flexuosus (Thurb.) Rydb. (SN) PNGb

Stipa comata Trin. & Rupr. (SN 80; JF 180, 3 June 1977) PNGbk

Vulpia octoflora (Walt.) Rydb. (SN; JF 269, 18 May 1977) ANGBik

Juncaceae

Juncus balticus Willd. (JF 171, 16 June 1977) PNGLbi

Juncaginaceae

Triglochin maritima L. (JF 227, 26 June 1977) PNGLi

Liliaceae

Allium macropetalum Rydb. (JWB NB 11, 20 May 1939; SN 326, 20 June 1973) PNFb

Calochortus nuttallii Torr. & Gray (SN 99, 10 June 1972; JWB NB 13, 10 June 1939) PNFb

Fritillaria atropurpurea Nutt. (SN 287, 23 May 1973; MW 287, May 1930) PNFb

Smilacina stellata (L.) Desf. (MW Y-4; SN 148, 3 July 1972; SN 223, 3 July 1972; JF 154, 30 June 1977) PNFbk

Yucca angustissima Engelm. (SN 56, 9 June 1972; JWB NB 76, 21 June 1941) PNSbik

Yucca baccata Torr. (SN 315, 19 June 1973) PNSb

Orchidaceae

Habenaria sparsiflora S. Wats. (SN 167, 1 July 1972) PNFb

Sparganiaceae

Sparganium eurycarpum

Engelm. (JF 226, 26 June 1977) PNGLi

LITERATURE CITED

ALLAN, J. S. 1977. The plant communities of Arches National Park. Unpublished Ph.D. dissertation, Brigham Young University, Provo, Utah. 98 pp.

BROTHERSON, J. D. 1967. A study of certain community relationships of *Eriogonum corymbosum* Benth. In: DC in the Uintah Basin, Utah. Unpublished master's thesis, Brigham Young University, Provo, Utah. 100 pp.

CAMPBELL, V. O. 1977. Certain edaphic and biotic factors affecting vegetation in the shadscale community of the Kaiparowits area. Unpublished master's thesis, Brigham Young University, Provo, Utah. 58 pp.

COOLEY, M. E. 1958. Physiography of the Glen-San Juan Canyon area, Part I. Plateau 31:21-33.

_____. 1962. Late Pleistocene and Recent erosion and alluviation in parts of the Colorado River system, Arizona and Utah. In: Geological Survey Research 1962: short papers in geology, hydrology, and topography, articles 1-59, pp. 48-50. United States Geological Survey Professional Paper 450-B. Washington.

DEAN, J. S. 1969. Chronological analysis of Tsegi phase sites in northeastern Arizona. Papers of the Lab. of Tree-ring Res. No. 3. University of Arizona Press, Tucson, Arizona. 207 pp.

FLOWERS, S. 1963. The lichen and moss flora of Betatakin Canyon and vicinity, Navajo National Monument, Arizona. University of Utah Div. of Biol. Sci. Misc. Papers No. 3. 10 pp.

GREGORY, H. E. 1916. The Navajo country: a geographic and hydrographic reconnaissance of parts of Arizona, New Mexico, and Utah. United States Geological Survey Watersupply paper. Washington.

_____. 1917. Geology of the Navajo country: a reconnaissance of parts of Arizona, New Mexico, and Utah. United States Geological Survey Professional Paper 93. Washington.

HACK, J. T. 1942. The changing physical environment of the Hopi Indians of Arizona. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University. Vol. 35, No. 1. Reports of the Awatovi Expedition, No. 1. Cambridge.

_____. 1945. Recent geology of the Tsegi Canyon. Appendix I in R. L. Beals, George W. Brainerd, and Watson Smith, Archaeological Studies in Northeast Arizona. University of California Press, Berkeley and Los Angeles.

HARSHBARGER, J. W., C. A. REPENNING, AND J. H. IRWIN. 1957. The stratigraphy and the uppermost Triassic and Jurassic rocks of the Navajo country. United States Geological Survey Professional Paper 291. Washington.

HARRINGTON, H. D. 1964. Manual of the plants of Colorado. The Swallow Press, Inc. Chicago, Illinois. 666 pp.

- KEARNEY, T. H., AND R. H. PEEBLES. 1960. Arizona flora. University of California Press. Berkeley, California. 1085 pp.
- MCDUGAL, W. B. 1973. Seed plants of northern Arizona. The Museum of Northern Arizona, Flagstaff, Arizona. 594 pp.
- SELLERS, W. D. 1964. The climate of Arizona. Pp. 3-64. *In*: Christine R. Green and William D. Sellers, eds., Arizona Climate. University of Arizona Press, Tucson, Arizona, 175 pp.
- WELSH, S. L. AND G. MOORE. 1973. Utah plants—Tracheophyta. Brigham Young University Press. Provo, Utah. 474 pp.
- WOODBURY, A. M. 1963. Biological-ecological aspects of Betatakin Canyon, Navajo National Monument, Arizona. University of Utah Div. of Biol. Sci. Misc. Papers No. 2. 56 pp.